



Guide to Electrical Safety Testing

Why Test?

There are four main reasons why you should safety test your products prior to shipment

1. Safety	Ensure that the product is not going to pose a hazard to the end user.
2. Quality	Detect workmanship defects and prevent faulty components from being installed.
3. Cost Control	Identify production problems before a product is shipped, preventing costly recalls.
4. Liability	Prevent product liability suits because the responsibility of performing electrical safety tests ultimately rests on the manufacturer.

NRTLs (Nationally Recognized Testing Laboratories) set standards outlining tests that must be performed on a product before it's considered safe for the consumer market. NRTLs implement and enforce electrical safety testing to protect consumers from a potentially fatal electric shock.



NRTL Examples: Underwriters Laboratories (UL - United States), TÜV Rheinland (Germany), Canadian Standards Association (CSA - Canada), ETL (Intertek - United States) and CCC (China Compulsory Certification - China)

NRTL standards dictate that electrical products incorporate two lines of defense to protect the user from electric shock

Insulation

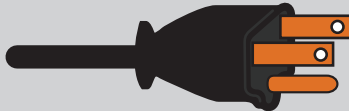
- Separates power lines from low voltage circuits.
- Separates power lines from isolated power supplies.
- Isolates input power from the chassis or case of an electrical device.

Safety Grounds

- Allow dangerous fault currents to return to system ground.
- Enables circuit breakers to open.
- Safeguards against fire.
- Protects against damage to electrical equipment.

Electrical products can be classified according to insulation type

Class I Products



- Terminate in 3 prong line cord (line, neutral and ground).
- Ground prong connects to product chassis.
- Safety through basic insulation and proper grounding.

Class II Products



- Double insulated products.
- Terminate in 2 prong line cord (line and neutral).
- Safety through dual layer of insulation.

NRTL standards generally specify two separate testing categories

Type Test	<ul style="list-style-type: none"> • Performed as a laboratory or prototype test. • Done on sample basis. • Used to detect defects in product design. • More rigorous testing.
Production Line Test	<ul style="list-style-type: none"> • Performed on 100% of products on the production line. • Used to detect manufacturing or workmanship defects.

As a manufacturer or test operator, it's up to you to ensure you have the proper knowledge and training to use high voltage equipment.

Before working with an electrical safety test station, you need to make sure you are a qualified operator according to OSHA guidelines¹.



Occupational Safety and Health Administration

An agency of the United States Department of Labor charged with ensuring safe working conditions as well as enforcing standards and providing workplace training and education.

OSHA 1910.332 Subpart S

<https://www.osha.gov>

Effects of electrical current on the human body

Current	Reaction**
0.5 to 1 milliamp	Perception.
5 milliamps	Slight shock felt, startled reaction.
6-30 milliamps	Painful shock and inability to let go.
30-150 milliamps	Extremely painful, respiratory arrest, ventricular fibrillation, death possible.
10 amps	Cardiac arrest, severe burns.

**** These effects are for voltages less than 600 volts. Many electrical safety testers can output voltages in excess of 5000 volts which can cause more severe reactions at lower current levels.**

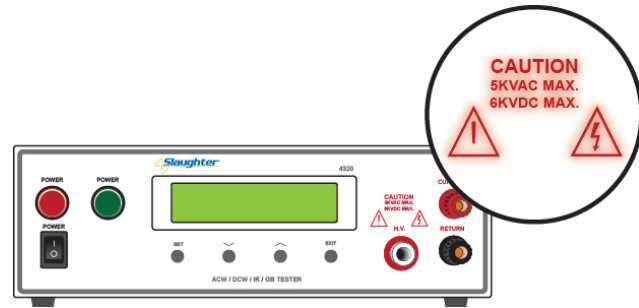
¹ OSHA 29 CFR part 1910.332 Subpart S defines the training requirements for anyone exposed to voltages in excess of 50 volts.

A Qualified Operator Must Know

Knowledge

Example

1. Determine whether an exposed conductor is energized or not.



Hipot tester with the output voltage ON. The CAUTION and HIGH VOLTAGE warning lights illuminate RED when the tester is active. This indicates that the tester is in a dangerous state.

2. Determine the nominal voltage of an electrical circuit by reading drawings, signs, and labels. Know how to use the equipment. Every tester should come with a user's manual.

Review this manual prior to using the equipment.



Product power cord with label displaying the nominal voltage and current of the device.

3. Understand approach distances and corresponding voltages to which you may be exposed.²

Slaughter testers can output up to 5000 VAC. Always review product specifications before using the equipment.

4. You should be trained to identify and understand the relationship between electrical hazards and possible injury.

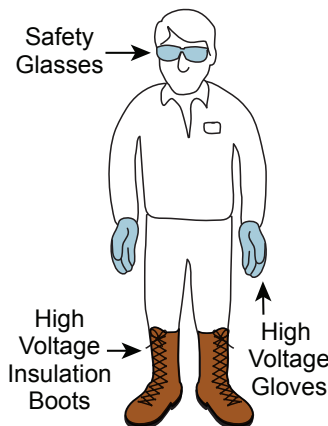
Refer to the table “Effects of Current on the Human Body” on the preceding page.

5. Know the safety features of the equipment and utilize them.

Most Slaughter testers have an automatic discharge circuit that will discharge the DUT in less than 200 msec after the test completes. This ensures the DUT is safe for you to touch once the test has completed.

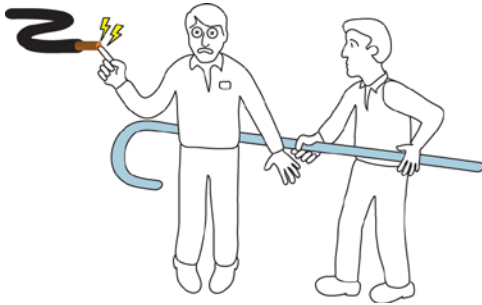
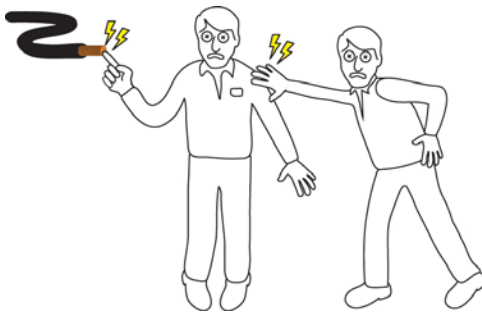
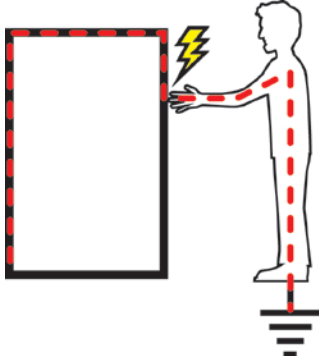
6. Determine if Personal Protective Equipment (PPE) is necessary, what type of PPE³ is necessary and how the PPE is rated. OSHA now requires in addition to being a Qualified Person, that you must wear PPE for protection from shock if you cross the Restricted Boundary.

Note: The restricted boundary for live parts operating between 751 V and 15 kV is 2 feet 2 inches.



The operator in this image is wearing high voltage gloves, safety glasses and high voltage boots. These are common examples of the PPE you should wear as an operator when using high voltage equipment.

A Qualified Operator Must Know

Knowledge	Example
<p>7. Know the methods of release for victims who are being shocked.</p>	<div data-bbox="537 218 1016 520">  </div> <p>Methods include using a non-conductive material (i.e. a fiberglass pole) to release someone from a live circuit. Using an E-Stop can also shut off power to the entire station and release the victim.</p> <div data-bbox="537 583 1016 892">  </div> <p>DO NOT touch a person who is being shocked or you could also become part of the circuit!</p>
<p>8. Understand that the tester is a variable voltage power source that will output current to any available ground path. Contacting the DUT during the test can result in a dangerous shock hazard.</p>	<div data-bbox="683 919 1000 1276">  </div> <p>This image shows someone contacting a live circuit. The current flows directly through their body to ground causing severe, possibly fatal injuries.</p>
<p>9. You must know the importance of discharging the DUT.</p>	<p>While all Slaughter testers do have an automatic discharging circuit, lifting the high voltage or return lead from the DUT before the test is complete can leave the DUT charged. If the Hipot does not have a complete circuit, it cannot discharge the DUT at the end of the test.</p>
<p>10. Understand that each step in the work plan must be executed as planned.</p>	<p>DO NOT TAKE SHORT CUTS!</p> <p>Refer to Test Station Safety Procedure Checklist to review your Hipot setup before you test.</p>



Additional Slaughter educational material

Slaughter Whitepapers

<http://www.hipot.com/support/our-resources.aspx>

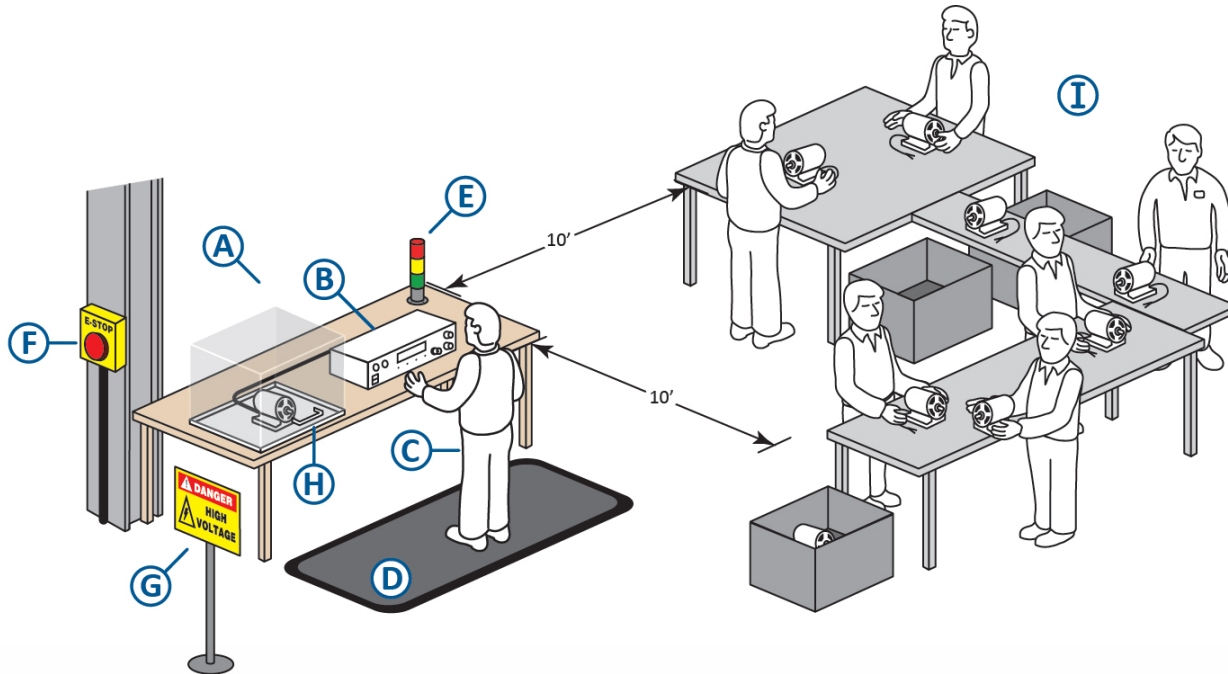
² NFPA 70E Table 130.2(C) outlines approach boundaries to live parts for shock protection.

³ NFPA 70E Section 130.7(C)(10) shall be used to determine the required PPE for the task.

Setting up a Safe Workstation

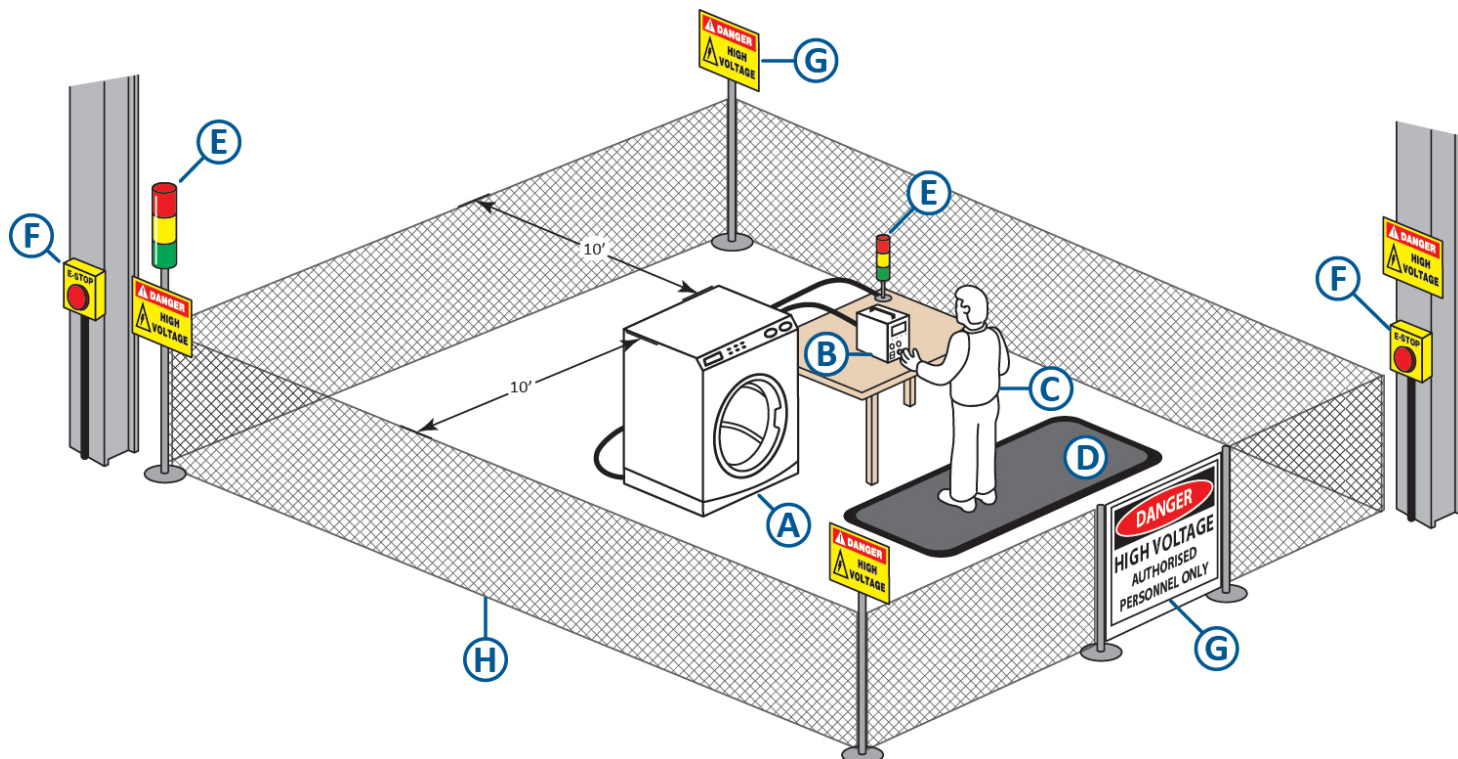
One of the best ways to prevent injury is to ensure that the test station is set up safely and securely. Test stations can be setup with or without direct protection depending on your requirements.

Direct protection means that the operator cannot physically come into contact with an energized DUT while a test is running.



Station with protection against electric shock.

Reference	Description
A	DUT Safety Enclosure - This is wired to the Hipot tester's Remote Safety Interlock. This protects you from touching the DUT while a test is in progress. If the enclosure door is opened, the tester's high voltage is immediately disabled.
B	Hipot Tester – tests the DUT.
C	Test Operator.
D	High Voltage Insulation Mat – This isolates you from ground which provides an additional means of protection when operating high voltage equipment.
E	Signal Tower Light – gives an indication as to the status of the testing area. A green light indicates the Hipot tester is not outputting high voltage and the test area is safe. A red light indicates that the Hipot tester is active and to stay clear of the test area.
F	Emergency Stop Button – An E-stop button is located on the perimeter of the test area. In the event of an emergency, someone outside the test area can hit the E-Stop button to immediately cut off power to the entire test station.
G	Warning Signs ⁴ – Mark the testing area with clearly posted signs that read: DANGER-HIGH VOLTAGE TEST IN PROGRESS. UNAUTHORIZED PERSONNEL KEEP AWAY.
H	Non-Conductive Work Bench – Only use a work bench made of non-conductive material such as plastic or wood. This ensures no stray leakage current could flow through you during a test.
I	NEC (National Electric Code) and NFPA (National Fire Protection Agency) ⁵ stipulate that any unqualified workers shall not come within 10 feet of an energized circuit.



Station without direct protection against electric shock.
Such a station does not protect the user from touching the DUT during a test

Reference	Description
A	DUT – This large DUT prevents you from using a product safety enclosure. Instead, other precautions must be taken to ensure a safe testing station.
B	The Hipot Tester – tests the DUT.
C	Test Operator.
D	High Voltage Insulation Mat – This isolates you from ground which provides an additional means of protection when operating high voltage equipment.
E	Signal Tower Light – gives an indication as to the status of the testing area. A green light indicates the Hipot tester is not outputting high voltage and the test area is safe. A red light indicates that the Hipot tester is active and to stay clear of the test area.
F	Emergency Stop Button – An E-stop button is located on the perimeter of the test area. In the event of an emergency, someone outside the test area can hit the E-Stop button to immediately cut off power to the entire test station.
G	Warning Signs ⁴ – Mark the testing area with clearly posted signs that read: DANGER-HIGH VOLTAGE TEST IN PROGRESS. UNAUTHORIZED PERSONNEL KEEP AWAY.
H	Sectioned Off Test Area – Since the size of the DUT restricts the use of an enclosure, this test area is sectioned off by a mesh fence to keep unauthorized personnel away from the testing station. NEC (National Electric Code) and NFPA (National Fire Protection Agency) ⁵ stipulate that any unqualified workers shall not come within 10 feet of an energized circuit.

⁴ High Voltage signs compliant to ANSI Z535-2011

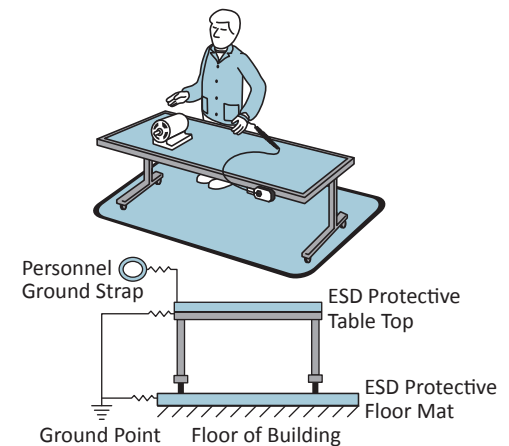
⁵ See NFPA 70E Table 130.2(C)

Important Information Regarding ESD Stations

WARNING

Do NOT setup electrical safety testing stations and ESD (electrostatic discharge) stations in the same area. ESD protocols are designed to protect a component or device from static discharge (not the operator from high voltage hazards).

Do NOT use anti-static robes, benches, or floor mats during electrical safety testing. All of these items are used to intentionally ground the test operator which can cause injury or death to a high voltage test operator. Such stations are not designed for voltages above 250 VAC.

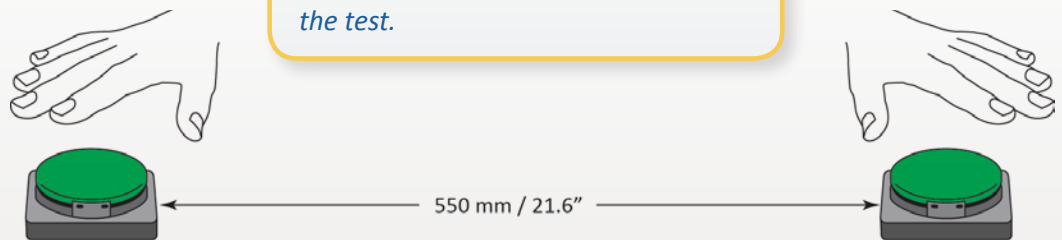


Additional Methods for Test Safety

In some cases, you may not be able to use a roped off test area or DUT enclosure. When necessary, there are other methods that you can use to protect your operators:

Dual Remote Palm Switches

Two hand operation switches force the operator to place a hand on each switch and hold them throughout the test. The palm switches should be placed at least 21.6 in (550 mm) apart to prevent the operator from one hand activation of both switches. Some switches have guards over the top to prevent one hand actuation and do not require a minimum distance of separation.

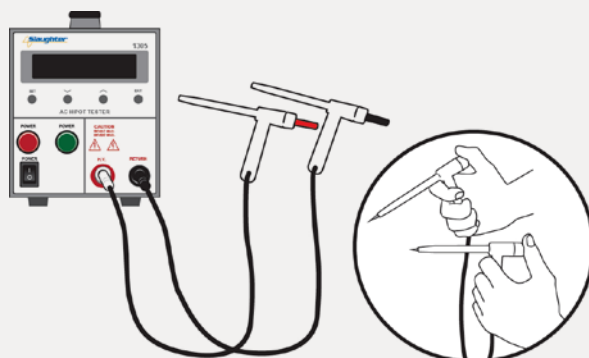


Why is this safe?

This does not allow the operator to touch the DUT as their hands must remain on the test switches during the test.

Safety Probes

Use extended probes to contact the DUT during a test. A push button on the probe extends a conductive tip for contact to the DUT.

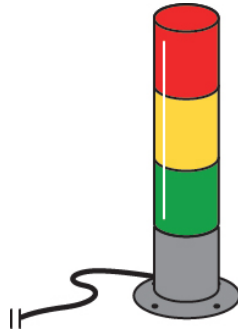


Why is this safe?

This forces the operator to hold extended probes so that they cannot touch the DUT or tester while a test is running.

Signal Tower Lights

These status lights illuminate RED when a test is running and GREEN when the test passes or the Hipot tester is idle. Refer to figures 1 and 2 for more information.

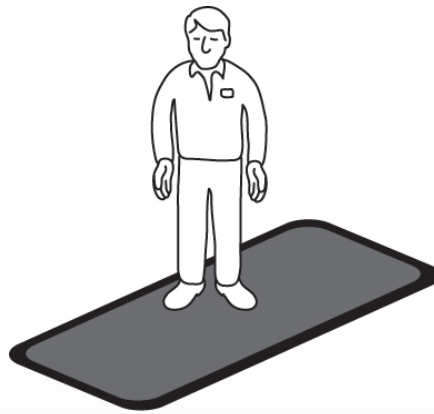


Why is this safe?

Mounted lights warn operators in the nearby area to the status of the Hipot test and if the tester is outputting high voltage.

Insulation Mats

High voltage insulation mats on the floor of the test area. The operator stands on the mat while testing.



Why is this safe?

The mat isolates the operator from ground while testing which greatly mitigates the shock hazard.

ALWAYS REMEMBER

- ✓ Keep unqualified and unauthorized personnel away from the testing area. If this is not possible, the unqualified person must be supervised by a qualified operator while they are in the test area.
- ✓ Arrange the testing area out of the way of routine activity. Designate the area clearly.
- ✓ Never touch the DUT or the connections between the DUT and the tester during a test.
- ✓ In the case of an emergency, or if problems arise, turn off the high voltage first.
- ✓ Properly discharge any DC-tested product before touching or handling connections.

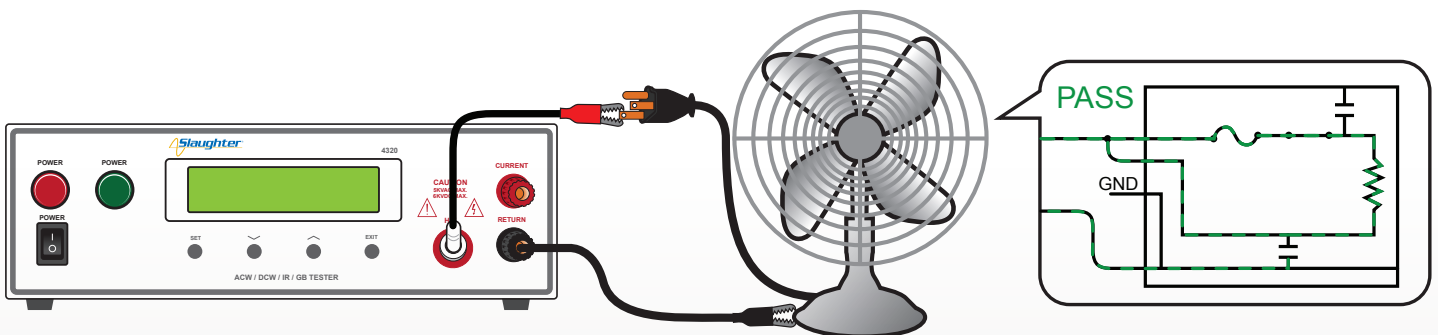
The Hipot⁶ Test (Dielectric Voltage Withstand)

The Hipot test is the most common type of safety test. This test is designed to stress a product's insulation beyond what it would encounter during normal use. The reasoning behind this test is that if the insulation can withstand high voltage for short period of time, it will be safe to use at nominal voltage throughout its useful life.

One of the main advantages of the Hipot test is its versatility. In addition to measuring leakage currents and detecting breakdowns, you can also use it to detect:

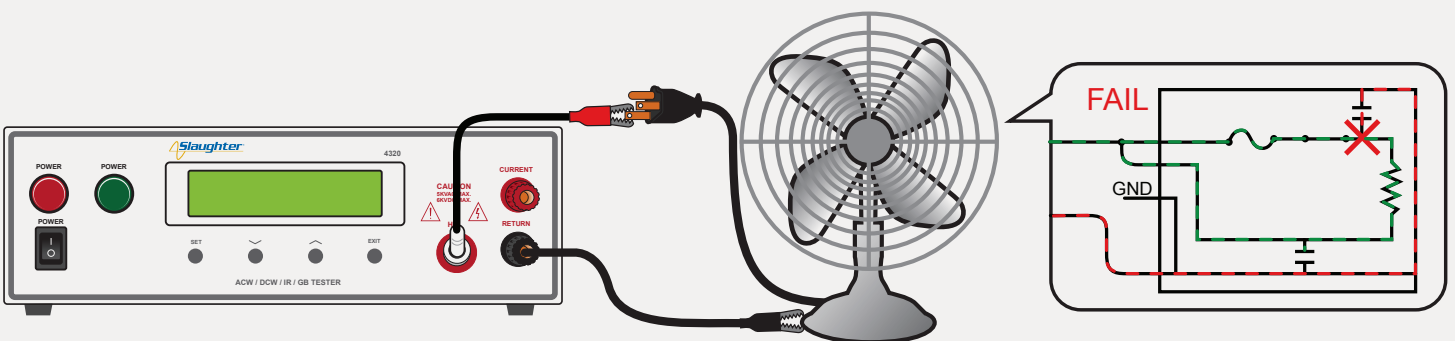
- **Material and workmanship defects.**
- **Weak points in the insulation.**
- **Small gap spacing between conductors. Air is just an insulator and Hipot voltage will “jump” through the air across gaps that are too small.**
- **Condensation, dirt and contaminants in the insulation.**

When running a Hipot test, high voltage is applied to the mains conductors (LINE and NEUTRAL). The Hipot return point is connected to the bare metal chassis of the fan. You're essentially creating a capacitor, where the product insulation is the dielectric material. The Hipot tester measures the resulting leakage current flowing through the insulation (represented as capacitors between mains and ground).



Leakage Current and Dielectric Breakdown

Any electrical device will produce small levels of leakage current due to the voltages and internal capacitance present within the product. Under normal circumstances this leakage current isn't large enough to be perceived by the human body. Yet due to design flaws or manufacturing defects the insulation in a product can break down, resulting in excessive leakage current flow. This is exactly what a Hipot test is designed to check.



Dielectric breakdown is defined as the failure of insulation to prevent the flow of current. The best indication of dielectric breakdown is a leakage current measurement significantly higher than the nominal current measurement. The maximum leakage current is dependent upon the test voltage; therefore, the leakage current will vary depending upon the product being tested.

⁶ “Hipot” comes from the combination of “High Potential”

General Hipot Test Considerations

Voltage

Hipot test voltage values will vary between products due to the nature of the insulation barrier. However, a good rule of thumb that most safety agencies use to determine the appropriate test voltage for an electrical product:

$$(\text{Hipot Test Voltage}) = (\text{Nominal Input Voltage}) * 2 + 1000 \text{ V}$$

For example, if the nominal voltage on a fan is 120 VAC, the test voltage would be 1240 VAC

Not sure about Hipot test voltage?

When in doubt, you should always refer back to the appropriate NRTL standard.

Test Time

Hipot test time (dwell time) can also vary between agency standards. The most common test durations are 1 sec for production tests and 1 minute for design tests. However, if the test time is reduced from 1 min to 1 sec, the Hipot test voltage generally needs to be raised by 20% since the insulation is being stressed for a shorter period of time.

The example below is from UL 1598 – Luminaires, outlining the voltage and time differences for a type and production line test.

UL 1598 – Dielectric Voltage-Withstand Test for incandescent type luminaires	
Test Time	Test Voltage
60 sec (Type)	1000 VAC
1 sec (Production)	1200 VAC

Current Limit

Most safety agencies do not specify leakage current limits. Here is valid method for determining proper leakage limit settings:

1. Perform a Hipot test on a sample of known good products. Record the leakage current results.
2. Calculate an average leakage current value from these samples.
3. Multiply the average value by 25%. Add this number to the average value.
This is your leakage current high limit.
4. Perform the same step, but now subtract 25% from the average value. This is your leakage current low limit.

AC vs. DC Hipot Tests

AC and DC Hipot tests have advantages and disadvantages that become evident depending on the characteristics of the DUT. The table below lists the advantages and disadvantages of each type of test.

AC HIPOT <i>Advantages</i>	DC HIPOT <i>Advantages</i>
✓ Slow ramping of the test voltage isn't necessary due to the changing polarity of the applied waveform.	✓ The test can be performed at a much lower current level, saving power and with less risk to the test operator.
✓ It is unnecessary to discharge the DUT after AC testing.	✓ Leakage current measurement is a more accurate representation of the real current. This is due to the insulation capacitance charging after the ramp up cycle.
✓ AC testing stresses the insulation alternately in both polarities. This makes it a more stringent Hipot test.	✓ DC testing is the only option for some circuit components such as diodes and larger capacitance values.
<i>Disadvantages</i>	<i>Disadvantages</i>
✗ Measures only the total leakage current (from capacitive and resistive elements).	✗ Must ramp up the test voltage so inrush leakage does not exceed Hipot tester's capability.
✗ Requires a larger Hipot transformer due to measuring the total leakage current.	✗ Must discharge the DUT at the end of the test.
	✗ Only stresses insulation in one polarity. Not as stressful of a Hipot test.
	✗ Not always accepted by safety agencies.

A Note on Procedural Differences

Since a Hipot test is stressing the insulation of a DUT with high voltage, the applied test voltage must be the same value whether it is AC or DC.

$$(\text{Hipot Test Voltage}) = (\text{Nominal Input Voltage}) * 2 + 1000 \text{ V}$$

For a DC test use the following formula to assure that the DC voltage is the same value as the peak of the AC waveform:

$$\text{DC Hipot Test Voltage} = (\text{AC Hipot Test Voltage}) * 1.414$$

Not sure about Hipot test voltage?

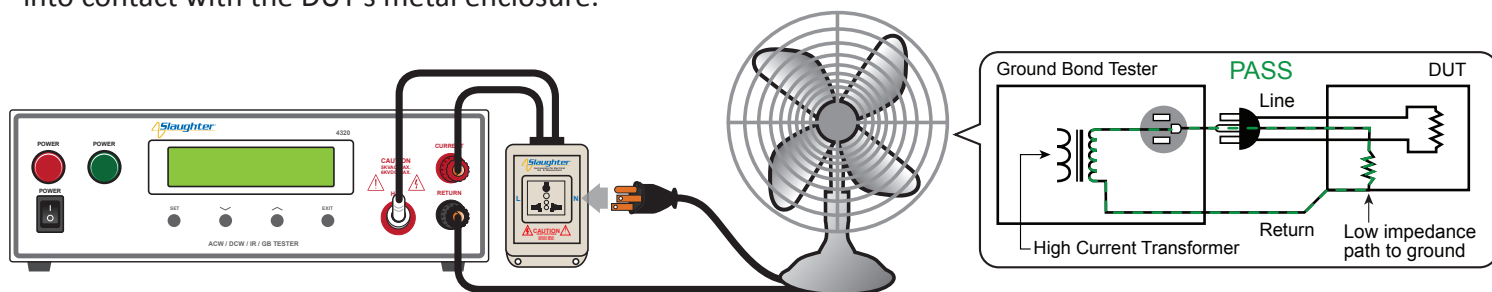
Always refer to the appropriate agency standard they may specify a different multiplier for the AC to DC hipot test voltage conversion.

Ground Continuity Test

The Ground Continuity test often are required to be performed along with or prior to the Hipot test. Its purpose is to ensure that the DUT's safety ground connections have been made properly. This test checks for a connection between the third prong on a line cord (Class I product) and the product chassis or case.

Ground Bond Test

The Ground Bond test determines whether the safety ground connection of a DUT can adequately handle the fault current resulting from insulation failure. By simulating a failure condition and circulating excessive current through the DUT's ground connection, the Ground Bond test helps to verify the integrity of the connection to earth ground. This means that potentially lethal fault current will flow to ground and not to a person that comes into contact with the DUT's metal enclosure.



During a Ground Bond test, high current flows from the ground pin of the DUT to the RETURN on the chassis. The Ground Bond tester then displays the resulting ground circuit resistance.

Ground Bond/Ground Continuity Test Considerations

Current and Voltage Drop

Testing a ground circuit with a ground bond or continuity test involves running current through the circuit and measuring the resulting voltage drop. Since all products have different current ratings, the current and voltage drop for the test will also vary. A general range for each value is specified across NRTL standards.

General Ground Bond/Ground Continuity test parameter values

Test Parameter	Value
Current	1.5-2.5 X tester current rating*
Voltage Drop	4 V-12 V
*May also indicate extra condition of current = 25-40 A. It depends upon which value is higher (the calculated value or 25-40 A value).	

This is illustrated in standards such as UL 60335-1 for household appliances. It stipulates a type test for ground bond:

Test Current = 1.5 X Rated Current for appliance

or

25 A passed between ground pin and product case, whichever value is higher. The voltage drop across the circuit is not to exceed 12 V.

For example, if my product has a rated current of 10 A, you would test the product at 25 A as $1.5 \times 10 \text{ A} = 15 \text{ A}$.

Not sure about the Ground Bond current or Voltage Drop values?

When in doubt, you should always refer back to the appropriate NRTL standard.

Test Time

The testing time for a ground bond and ground continuity test is left to the discretion of the manufacturer. Some standards do indicate a ground bond test time of 120 sec but most stipulate to run the test for the amount of time necessary to get a stable reading. If you’re running a higher current test (10 A or greater), it is recommended to run the test for at least 5-10 sec. If you’re running a low amperage ground continuity test, 1 sec is enough time to obtain a reading.

Resistance Limits

The idea behind a ground bond/ground continuity test is to measure the resistance to ground to ensure the value is low enough so fault current will flow. The majority of NRTL standards give a range of maximum resistance values depending upon the nature of the product’s ground wire or power cord.

Ground Bond/Ground Continuity test resistance limits	
Cord Type	Resistance Limit
Detachable power cord	0.1 Ω
Permanently connected power cord	0.2 Ω

Check your NRTL standards!

It’s important to remember that these values can vary from standard to standard. As a manufacturer, it’s up to you to check your standard to ensure proper testing parameters.

Ground Bond Vs. Continuity

Ground Continuity Test	Ground Bond Test
<ul style="list-style-type: none"> • Verifies the existence of a ground connection. • Readings generally given in Ωs. • The test is quick to set up and easy to perform. • Usually used as an extra feature during the Hipot test. 	<ul style="list-style-type: none"> • Verifies the integrity of a ground connection. • Readings generally given in $m\Omega$. • Provides more valuable safety information about DUT. • Can be combined with a Hipot test for a more complete safety testing system.

The Ground Continuity test does have limitations when it comes to testing the integrity of the ground conductor. Take the example of a line cord that has a 64 strand braided ground conductor wire . What if all of the strands were broken except for one?



A Ground Continuity test could pass a product that has only 1 strand of wire connecting its chassis to ground.



If a fault were to occur, this connection wouldn't be capable of handling the input current to the product and could create an open ground condition. A ground bond test would fail this test because the single wire would not be able to handle the high current and would burn up.



For this reason, many electrical product manufacturers have been turning to the Ground Bond test as a more thorough alternative to the Ground Continuity test.

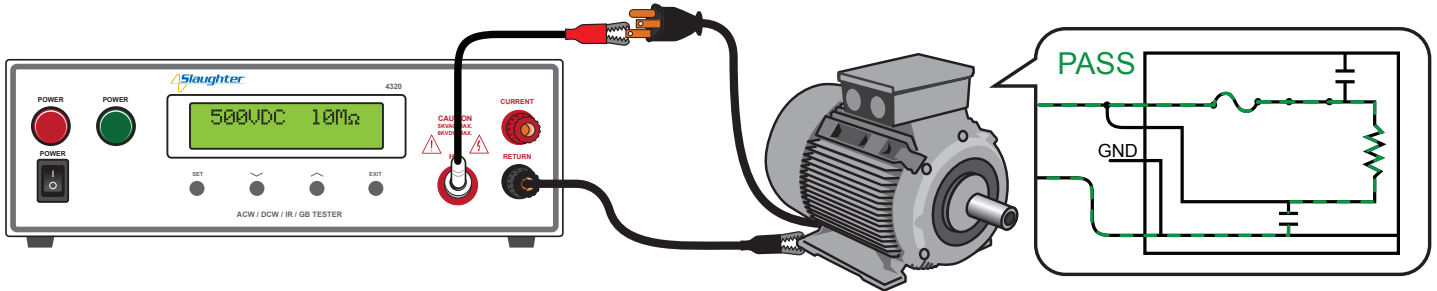
**Not sure whether you need
Ground Continuity or Ground
Bond?**

We're here to help!

Technical Support: +1 (800) 504-0055

The Insulation Resistance Test

The Insulation Resistance (IR) test is used to provide a quantifiable value for the resistance of a product's insulation. The tester applies a DC voltage across the insulation of a product and measures the corresponding leakage current in order to calculate a resistance value.



Although most IR testers have a variable output voltage, the test is usually specified at 500 or 1000 volts.

The IR test is sometimes required by safety agencies to be performed subsequent to the Hipot test in order to make sure that the DUT's insulation was not damaged as a result of the high voltage applied to it.

Insulation Resistance Test Considerations

There are a few things to keep in mind when running an IR test:

- ✓ Since most products are capacitive in nature it is important to allow the test to run for an adequate period of time before recording any measurements. Test times can vary but a 1-10 min test should supply a stable reading.
- ✓ It is always a good idea to ramp up the voltage over a period of time. This ensures the DUT is not subjected to a voltage surge that could damage it. This will also help avoid false failures due to inrush current (as with the DC Hipot test).
- ✓ The most important parameter for the IR test is the resistance low limit. If the resistance is too low, more current will flow and the test will fail. Remember, the higher the resistance, the better the insulation. If no IR value is specified by an agency specification, the insulation resistance for an IR test at 1000 V or less should be at least 1 MΩ.

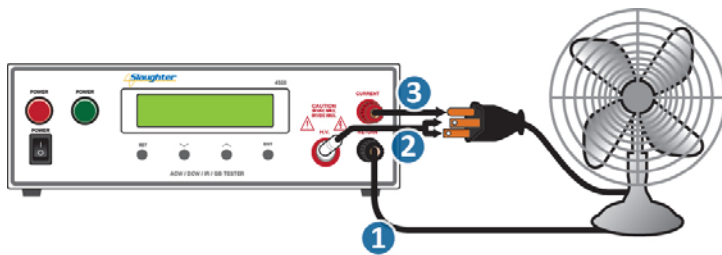
UL/IEC 60335-1: Household Electric Appliances

A fan needs to be tested on the production line per the UL/IEC 60335-1 standard. The fan runs from a 120 V and is a Class I product (3 prong cord with basic insulation).

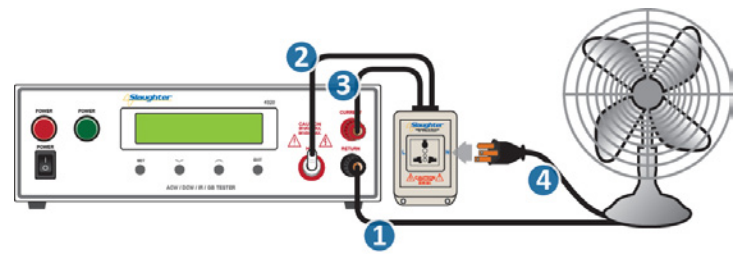
60335 Production Line Test Parameters

Test Type	Dielectric Withstand			Ground Bond			
Parameters	Test Voltage	Max Leakage Current	Test Time	Test Current	Voltage Limit	Maximum Resistance	Test Time
	800 VAC	5 mA	1 sec	10 A	<12 V	0.2 Ω	5 sec

Before testing, turn on all power switches on the appliance so that all internal circuits are tested. Ensure the appliance is disconnected from all other circuits.



60335 Testing Example Setup
Using Test Leads



60335 Testing Example Setup
Using Adapter Box

Test Procedure:

1. Connect the RETURN lead from the test tester to the metal chassis of the DUT. This will act as the return point for both the Hipot and the ground bond tests.
2. If using test leads, connect the line and neutral (shorted together) of the fan's three prong cord to the high voltage terminal of the Hipot tester. If using a universal style adapter box, connect the high voltage lead of the adapter box to the HV port on the tester. High voltage will be applied to the line and neutral plug conductors shorted together.
3. If using test leads, connect the ground pin of the fan to the HIGH CURRENT or CURRENT terminal on the ground bond tester. If using a plug in style adapter box, connect the high current lead of the adapter box to the CURRENT port on the tester. Current will be injected into the ground pin when using an adapter box.
4. Plug the fan's three prong cord into the box if using the plug in style adapter box.
5. First, the ground bond test is run to ensure that the grounding circuit is sufficient for the product. Set the ground bond test to the parameters listed above.
6. Set the Hipot test to the parameters listed above.
7. Stand back from the DUT and press the TEST button. Take note of the test results.

RV Testing

The R.V.I.A (Recreation Vehicle and Industry Association) sets forth testing to cover 120 VAC Electrical Systems. The R.V.I.A. bases this testing off of the National Electrical Code Article 551:

R.V.I.A (NEC 2011 Article 551) Section 551.60 Factory Tests (Electrical):

R.V.I.A Section 551.60 – Dielectric Voltage-Withstand Test for Recreational Vehicles⁷

Test Time	Test Voltage AC	Test Voltage DC
60 sec	900 V	1280 V
1 sec	1080 V	1530 V

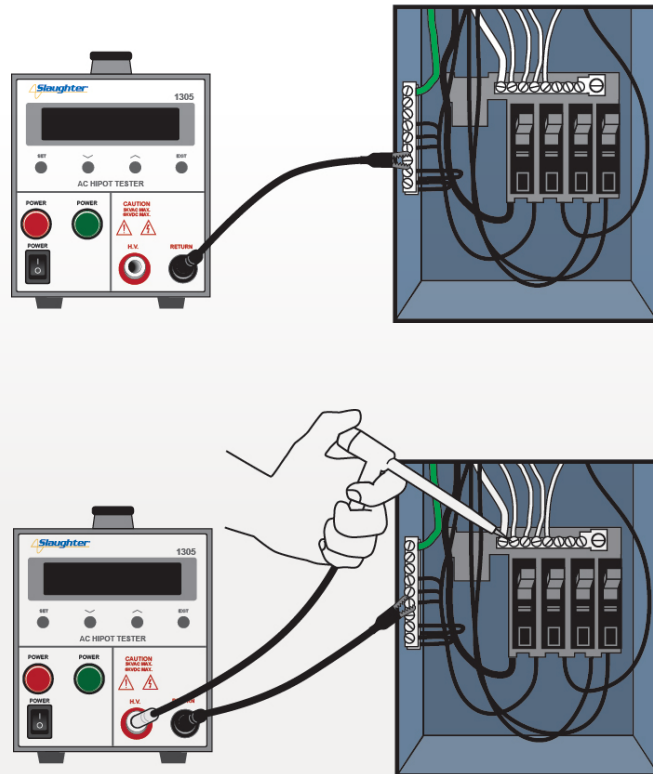
⁷ All switches and other controls shall be in the “on” position. Fixtures, including luminaries and permanently installed appliances, shall not be required to withstand this test.

This Hipot test will generally be run at the breaker box of the R.V. In recent years, more manufacturers have adopted the DC Hipot test due to the fact that all lights and appliances can remain installed in the R.V. during the test. An AC Hipot test could potentially damage such components. For AC testing, such elements usually have to be removed which adds considerable difficulty and complexity to the production line.

For this example, an operator will test an RV with a DC Hipot tester. The operator will use a safety test probe and alligator clip style RETURN lead.

Test Procedure:

1. Connect the RETURN lead to the grounding point in the breaker box
2. Set the Hipot test for 1530 VDC. Set the test time for 1 sec.
3. Contact the first breaker with the Hipot safety probe.
4. Push the test button and wait for the test to complete.
5. Repeat steps 3 and 4 for all breakers in the RV.



R.V.I.A. Information

Recreation Vehicle Industry Association Standards
<http://www.rvia.org>

Mobile Home Testing

With the regulations put in place by the U.S. Department of Housing and Urban Development (HUD), Hipot testing is important to modular and mobile home manufacturers:

H.U.D. #24 CRF 3280.810(a)– Dielectric Voltage-Withstand Test for Recreational Vehicles⁹

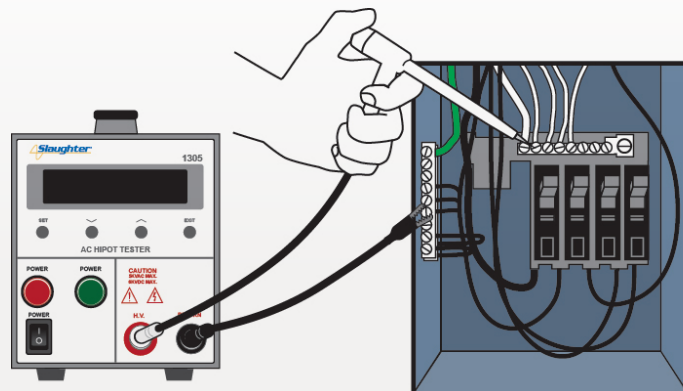
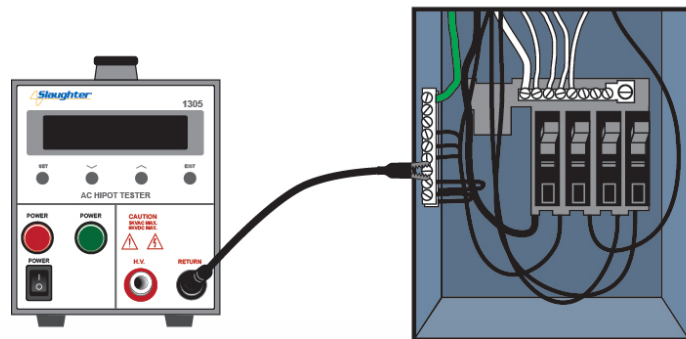
Test Time	Test Voltage
60 sec	900-1079 V
1 sec	1080-1250 V

The test is conducted between the live parts and the manufactured home's ground, as well as between the neutral and the manufactured home's ground. It is important to refrain from conducting the test from phase to phase or between hot and neutral in order to avoid damage to any appliances that might be connected.

As with the R.V. test example, this test is generally performed at the breaker box of the modular home.

Test Procedure:

1. Connect the RETURN lead to the grounding point in the breaker box.
2. Set the Hipot test for 1250 VAC.
Set the test time for 1 sec.
3. Contact the first breaker with the Hipot safety probe.
4. Push the test button and wait for the test to complete.
5. Repeat steps 3 and 4 for all breakers.



H.U.D. Testing Information

Manufactured Home Construction And Safety Standards
<http://www.ecfr.gov>

UL 1598 and IEC 60598 – Luminaires

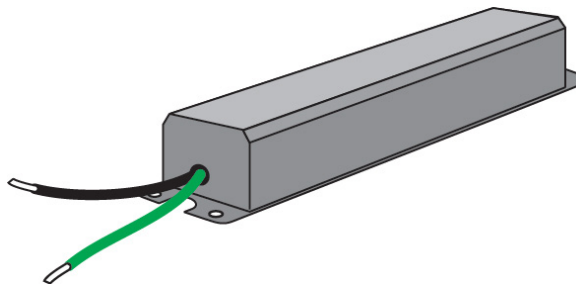
A fluorescent lamp ballast assembly needs to be tested for Hipot. The ballast has an input voltage range of 120-277 VAC. According to UL 1598 section 17.1.3:

“The test voltage shall be 1000 V for incandescent type luminaires and 1000 V plus twice the rated input voltage for all other types of luminaire.”

Since this is not incandescent type ballast, the test voltage would be:

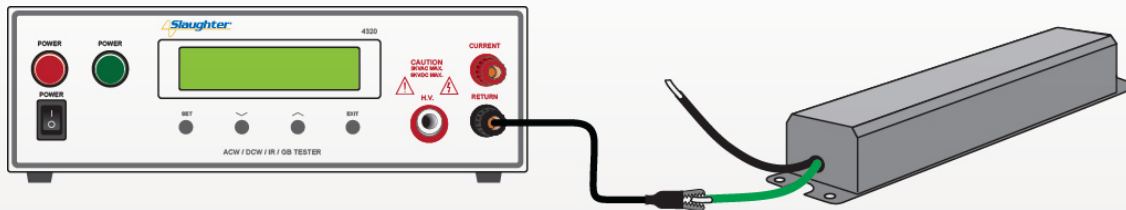
$$1554 \text{ VAC} = 1000 \text{ VAC} + 2 * 277 \text{ VAC}$$

LED Ballast

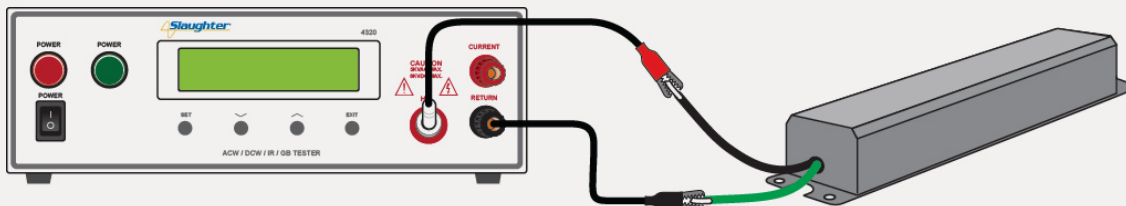


Test Procedure:

1. Connect the RETURN lead of the Hipot tester to the metal chassis of the ballast. Often times, the chassis is connected to a green grounding wire. This will provide the return point for leakage current to flow and the tester to take a reading.



2. Connect the white and black wires (shorted together) of the ballast to the high voltage lead of the Hipot tester. This puts all of the mains circuits in the ballast at high potential.



3. Set the Hipot test to the parameters per UL 1598 section 17.1.3.
4. Stand back from the DUT and press the TEST button.

Test Station Safety Procedure Checklist

Prior to Testing

- ✓ Verify the high voltage output is OFF before making any connections.
- ✓ Visually inspect test lead for signs of excessive wear. If a test lead appears worn or damaged, do not use it. Find a replacement lead.
- ✓ Connect the low return side to the tester first in order to prevent the DUT from becoming energized.
- ✓ If using alligator style clips leads, securely connect the clip lead to the exposed metal parts being tested.
- ✓ If using an tester with a panel mounted receptacle, first connect the return clip lead and then plug the product's cord set into the tester.
- ✓ When using a test fixture, be certain that it is properly closed and that all guards are in place.
- ✓ Double check the connections before beginning a test.
- ✓ Double check all tester settings before the test.

While Testing

- ✓ Handle both return and high voltage clips by their insulating material; never by the conductive metal.
- ✓ Keep the leads on the bench as close to the DUT as possible and avoid crossing test leads.
- ✓ Neatly coil any excess lead halfway between the tester and the DUT.
- ✓ Never touch any of the cables, connections or DUT's during a test.
- ✓ Have a "hot stick" on hand when doing DC testing (a hot stick is a non-conducting rod about two feet long with a metal probe connected to ground at one end). If a connection comes loose during the test, use the "hot stick" to discharge any surface that contacted the tester's hot lead – simply turning off the power is not sufficient.
- ✓ After the test, turn off the high voltage.
- ✓ Discharge DC-tested products for the proper length of time.

General Items

- ✓ Develop a standard test procedure and always follow it; don't take any shortcuts.
- ✓ Turn off the test tester if it is not in use.

Safety Reference Chart

Standard / Harmonized Standard	Testing Type	Dielectric Withstand			Ground Bond/Continuity				Earth Leakage		Insulation Resistance			Slaughter Model #
		Test Voltage	Max I.	Test Time	Test Current	V Limit	Max. R	Test Time	Test Voltage	Max I.	Test Time	V Limit	Min R	
IEC/UL 60601-1 3rd Edition Medical Electrical Equipment	Performance	500 – 4000 VAC or 707 – 5656 VDC	No Breakdown	60 s	10-25 A	≤ 6 V	≤ 0.1 Ω	5 s	110% x rated V	5-10 mA		N/A		6330
	Production	1000 – 3000 VAC		1 or 60 s	10-25 A	≤ 6 V	≤ 0.1 Ω	5 s	N/A			N/A		4320, 4520
H.U.D. Specification #24 CFR 3280.810	Performance	900-1079 VAC or 1273-1526 VDC	No Breakdown	60 s	Continuity				N/A			N/A		1305, 1340, 2503, 2510, 2550
	Production	1080-1250 VAC or 1527-1768 VDC	No Breakdown	1 s	Continuity				N/A			N/A		1305, 1340, 2503, 2510, 2550
R.V.I.A. (NEC)	Performance	900 VAC or 1280 VDC	No Breakdown	60 s	Continuity				N/A			N/A		1305, 1340, 2503, 2510, 2550
	Production	1080 VAC or 1530 VDC	No Breakdown	1 s	Continuity				N/A			N/A		1305, 1340, 2503, 2510, 2550
IEC 60335-1 Household Electrical Appliances	Performance	500 – 2400 VAC x rated V + 2400 VAC	No Breakdown	60 s	≥ 10 A	≤ 12 V	0.1 – 0.2 Ω	≤ 120 s	1.06 x rated V	0.25 – 5.0 uA		N/A		6330, 2525
	Production	400 – 2500 VAC	5-30 mA	1 s	≥ 10 A	≤ 12 V	0.1 – 0.2 Ω	No time specified	N/A			N/A		4520
UL 60335-1 Household Electrical Appliances	Performance	500 V – 2400 VAC x rated V + 2400 VAC	No Breakdown	60 s	40 A	≤ 6.5 V	≤ 0.5 Ω	120 s	1.06 x rated V	0.25 – 5.0 uA		N/A		6330, 2525
	Production	400 – 2500 VAC	5-30 mA	1 s	40 A	≤ 12 V	0.1 – 0.2 Ω	No time specified	N/A			N/A		4520
IEC 60598-1 Luminaires	Performance	500 – 4 x rated V + 2000 VAC	No Breakdown	60 s	≥ 10 A	≤ 12 V	≤ 0.5 Ω	60 s	Rated V	0.5 – 10 mA	60 s	500 VDC	1-4 MΩ	6330
	Production	Not Specified - Responsibility of Manufacturer												2955, 2965, 2975
UL 1598 Luminaires	Performance	1000 VAC - 1000 VAC x 2 x rated V	No Breakdown	60 s	30 A	≤ 4 V	≤ 0.1 Ω	120 s	N/A		No time specified	500 VDC	≥ 2 MΩ	4320, 4520
	Production	1200 VAC		1 s	Continuity		≤ 0.1 Ω	Continuity	N/A			N/A		2955, 2965, 2975
IEC/UL 61010-1 & CSA 22.2 No. 61010-1 Laboratory Control Test & Measurement Equipment	Performance	840 - 11940 VAC or 1200 - 7500 VDC	No Breakdown	5 - 60 s	25 or 30 A	≤ 10 V or ≤ 12 V	≤ 0.1 Ω or < 4 V 0.133 Ω	60 or 120 s	< 300 V	0.5 mA		N/A		6330
	Production			5 s max ramp up 2 s dwell	Continuity				N/A			N/A		2965, 2975
EN 60204-1 Electrical Equipment of Machines	Performance	2 x rated V or 1000 VAC	No Breakdown	1 s	0.2 - 10 A	≤ 24 V	Refer to Section 18.2.2	No time specified	N/A		No time specified	500 V	≥ 1 MΩ	4320, 4520
	Production	Not Specified - Responsibility of Manufacturer												1340, 2503, 2550, 2955, 2965, 2975
UL 45A Portable Electrical Appliances	Performance	1000 VAC + 2 x rated V or DC equivalent	No Breakdown	60 s	Continuity				< 300 V	0.5 – 3.5 mA	60 s	500 V	≥ 50 KΩ	6330
	Production	1000 - 3000 VAC		1 s	Continuity				N/A			N/A		1340, 2503, 2510, 2550, 2955, 2965, 2975
EN 60950-1 EN 50116 Information Technology Equipment	Performance	1000 – 3000 VAC or 1414 – 4242 VDC	No Breakdown	120 s	30 A	≤ 12 V	≤ 0.1 Ω	60 s	< 300 V	0.25 – 3.5 mA	60 s	500 V	≥ 2 MΩ	6330
	Production			1 - 4 s	25 A	≤ 12 V	≤ 0.1 Ω	1-4 s	N/A			N/A		4320, 4520
UL 60950-1 CSA 22.2 No. 60950-1 Information Technology Equipment	Performance	1000 – 3000 VAC or 1414 – 4242 VDC	No Breakdown	60 s	≤ 40 A	≤ 12 V	≤ 0.1 Ω	60 s	< 300 V	0.25 – 3.5 mA	60 s	500 V	≥ 2 MΩ	6330
	Production			1 – 6 s	Continuity				N/A			N/A		1340, 2503, 2510, 2550, 2955, 2965, 2975

GLOSSARY

Alternating Current - is the flow of electric current which reaches a maximum in one direction, decreases to zero, then reverses itself and reaches a maximum in the opposite direction. The cycle is repeated continuously, changing polarity and magnitude with time.

Breakdown - Catastrophic failure of a product's insulation resulting in excessive leakage current flow.

Class I Product - A product in which an additional safety precaution is provided in the form of a connection of the equipment to earth ground. The protective earth conductor in the fixed wiring of the line cord is attached to the chassis in such a way so that all accessible metal parts cannot become live in the event of a failure of the basic insulation.

Class II Product - A product that contains additional safety precautions such as double insulation or reinforced insulation. There are no provisions for protective earthing or reliance upon installation conditions, for these products.

DC - Direct Current - The flow of continuous electric current in one direction that can change in magnitude but not polarity.

Design/Type Test - A safety test performed on a prototype model during the design phase of the product.

Dielectric - An insulator sandwiched between two conductors. In the case of a Hipot test, the DUT's insulation is considered to be a dielectric.

DUT - Device Under Test

Ground Bond Test - A high current test that checks the integrity of a Class I product's safety ground connection.

Ground Continuity Test - A low current test that verifies a Class I product's safety ground connection is continuous.

Hipot Test - A high voltage test used to stress the insulation of a product and measure the resulting leakage current.

Insulation - A material that is a poor conductor of electricity. Used to isolate electrical circuits from ground and each other.

Insulation Resistance Test - A high voltage test used to record the resistance of a product's insulation.

Leakage Current - Current that leaks through a product's insulation to ground.

Nationally Recognized Testing Laboratory (NRTL) - Independent or Federally-associated regulatory agencies that create and oversee electrical safety testing.

NRTL Listing - Certification that a sample product has been tested by an independent third party agency (National Recognized Testing Laboratory) and has complied with national standards applicable to that particular product. Once certified, an agency label may be applied to the product to indicate compliance.

Production/Routine Test - A test performed on 100% of manufactured products after they are assembled, but before shipment.

Safety Ground - An extra low-impedance connection from the metallic chassis of a product to earth ground. Acts as a current path under fault conditions.

Questions about technical definitions?

We're here to help!

Technical Support: +1 (800) 504-0055

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